

INSTRUCTION
MANUAL
FOR.....

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AIL TYPE 70

WAVEGUIDE NOISE GENERATOR



70W Revision A

Caton
AIRBORNE INSTRUMENTS LABORATORY

DEER PARK, LONG ISLAND, NEW YORK 11729

A DIVISION OF CUTLER-HAMMER



AIL/
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WARRANTY

Except for tubes, fuses, and batteries which carry no warranty, Cutler-Hammer, in connection with equipment sold, agrees to correct any defect in workmanship or material which may develop during the period of one year from the date of shipment under proper or normal use and not in excess of the original manufacturer's life expectancy ratings, by its option to repair or replace, FOB point of shipment, the defective part or parts, and such correction shall constitute a fulfillment of all Cutler-Hammer liabilities in respect to said apparatus.

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I. INTRODUCTION

The AIL Type 70 Waveguide Noise Generators are sections of standard waveguide housing argon-filled gas-discharge tubes (Figure 1). Except for the P/N 07096, each noise generator is supplied with a removable termination.

These assemblies provide a known amount of random noise uniformly distributed over the frequency range of each generator.

These units, together with auxiliary equipment, can be used to evaluate the noise performance of amplifiers, receivers, and receiver systems.

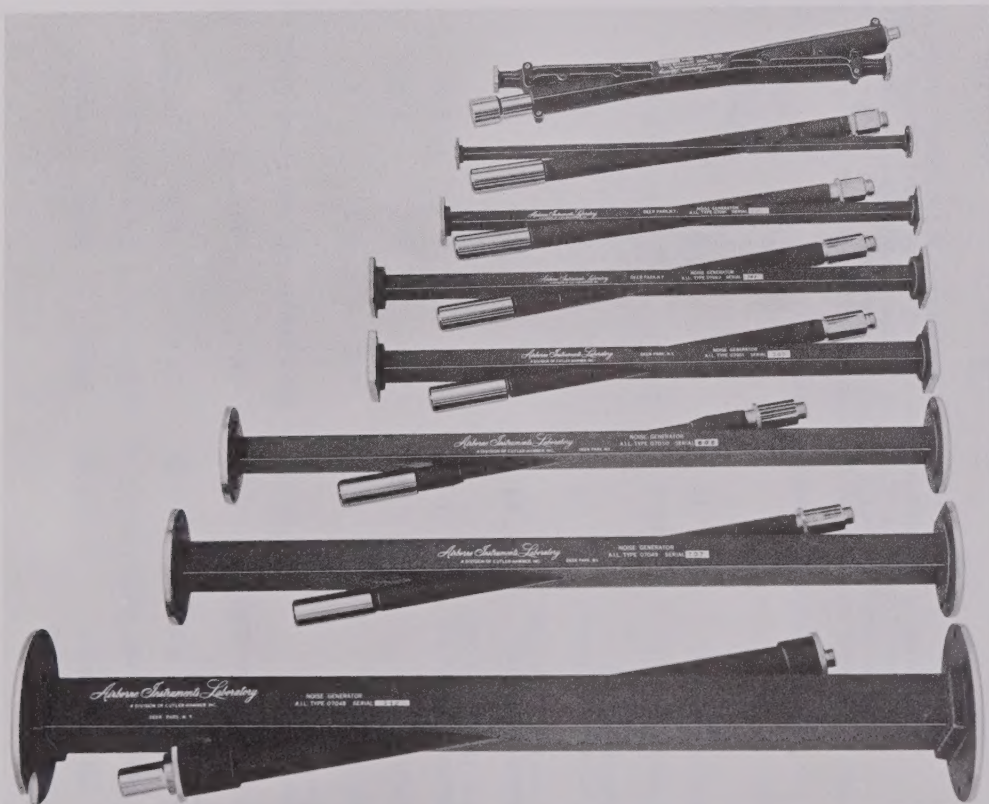


FIGURE 1. TYPE 70 WAVEGUIDE NOISE GENERATORS

II. SPECIFICATIONS

Part Number*	07048	07049	07050	07051	07052	07091	07053	07096
Frequency Range (GHz)	2.6-3.95	3.95-5.85	5.85-8.2	7.05-10.0	8.2-12.4	12.4-18.0	18.0-26.5	26.5-40.0
Excess Noise Ratio Tube Only (dB)	15.35	15.6	15.65	15.75	15.75	16.15	16.15	16.3
Anode Current (mA)	200	175	175	175	175	150	150	100
Noise Output Connections	UG-53/U	UG-149A/U	UG-344/U	UG-51/U	UG-39/U	UG-419/U	UG-425/U	UG-599/U
Unfired SWR	1.3	1.3	1.3	1.3	1.3	1.3	1.35	1.3
Fired SWR	1.2	1.2	1.2	1.2	1.2	1.2	1.35	1.2
Maximum Unfired Insertion Loss (dB)	1	1	1	0.5	0.5	1	1	1
Minimum Fired Insertion Loss (dB)	13	12	15	12	20	12	15	15
Termination Power Rating (watts)	15	8	6	5	4	1.5	.5	-
Length (inches)	28-1/4	24-1/4	22-3/4	18-1/4	19-1/4	13-1/2	13-1/4	13-1/2
Weight (pounds)	14	7	3 1/2	4	4	4	3	4

Table 1

* Part number indicates waveguide size.

Note: The excess noise ratios listed herein and in Section VI are only for the noise tubes. The tube manufacturer's production tolerance is ± 0.25 dB. To this must be added the comparison tolerance of his calibration equipment--typically, ± 0.15 dB, and the uncertainty of the excess noise ratio of his National Bureau of Standards calibrated standard, ± 0.1 dB. The absolute accuracy of the excess noise ratios listed then, is about ± 0.5 dB.

13506
@ 106 Hz -7.8 dB -3507
@ 90 Hz -7.6 dB -13546
13547

7-11 GHz
8.2 -12.4 GHz
12.4 -18.6 GHz

8059/
T072
Bend 4
F092
Signal 72
F092

III. OPERATING INSTRUCTIONS

The Type 70 Waveguide Noise Generators can be operated with the Type 71 Power Supply (Part No. 07111), the Type 74A Automatic Noise Figure Indicator (Part No. 07410), or the Type 75 Precision Automatic Noise Figure Indicator (Part No. 07510). Refer to the handbooks for the preceding instruments for instructions on connecting and operating the noise generators.

The excess noise ratio and operating current for each model are given in the specifications (Section II).

All AIL Type 70 Waveguide Noise Generators, with the exception of the P/N 07096, are provided with terminations. Before operating the 07096 it is necessary to connect one end to a termination with a SWR of less than 1.1.

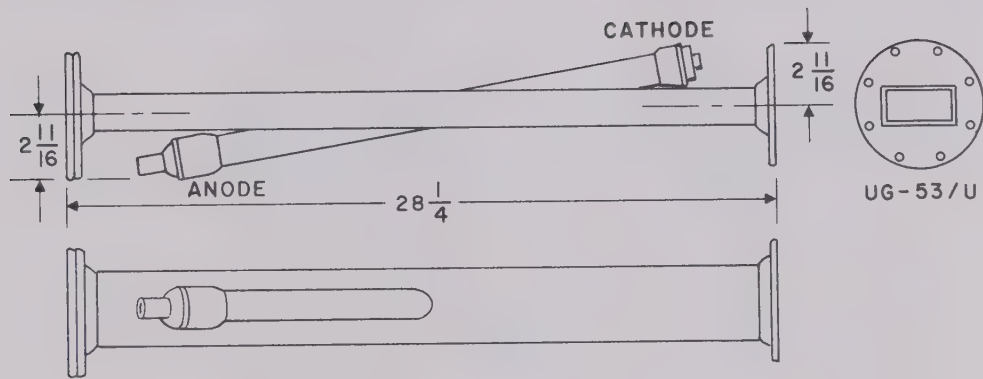
For certain applications, it may be desirable to inject a test signal into the system under test through the noise generator. The internal terminations may be removed for this purpose. Simply remove the bolts holding the termination flange to the noise generator and remove the termination. The signal generator connected to the unused flange should exhibit a SWR of less than 1.1 when it is turned off.

The terminations should be stored with some care when not in use. These devices are somewhat fragile and can be damaged quite easily through mishandling.

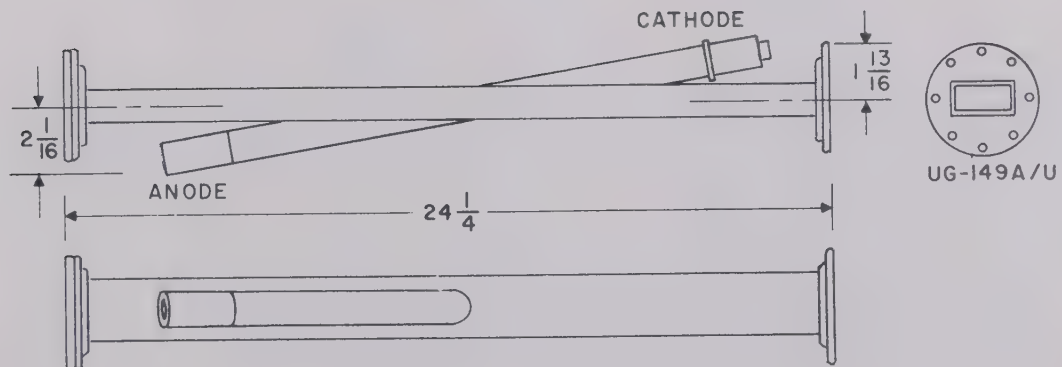
IV. OUTLINE DIMENSIONS

DIMENSIONS IN INCHES

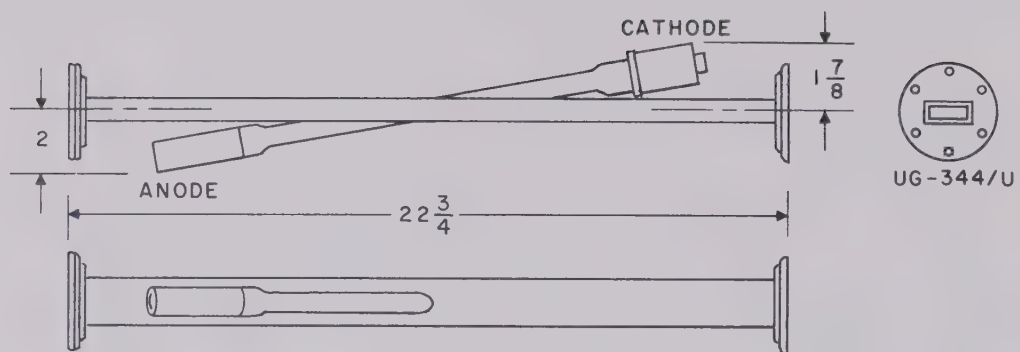
DIMENSIONS IN INCHES



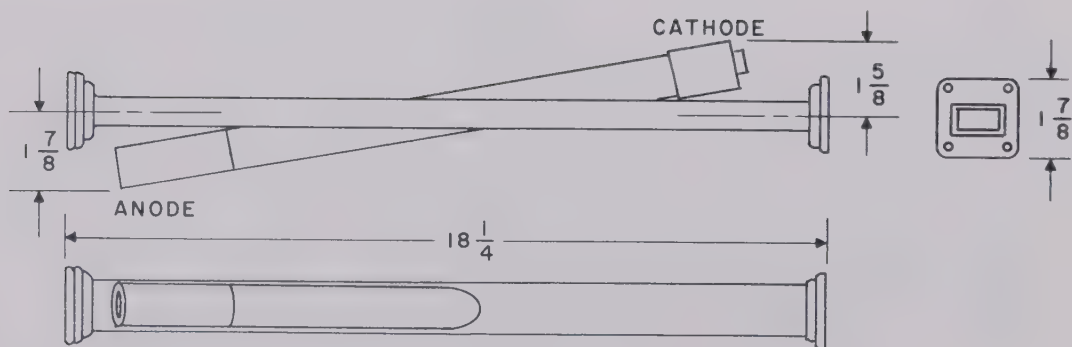
07048



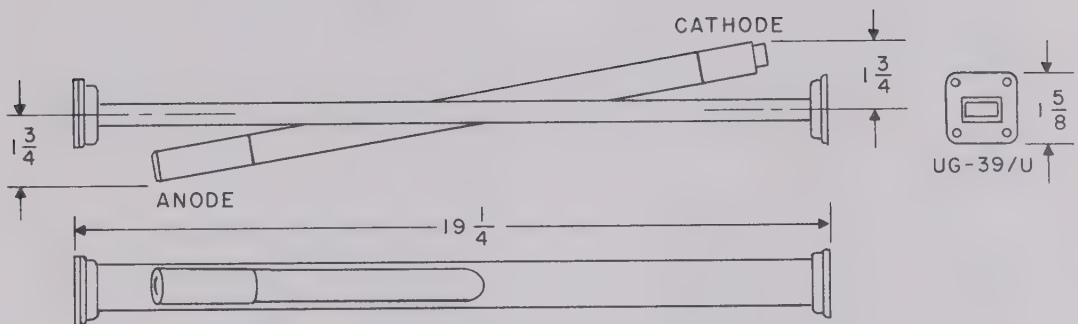
07049



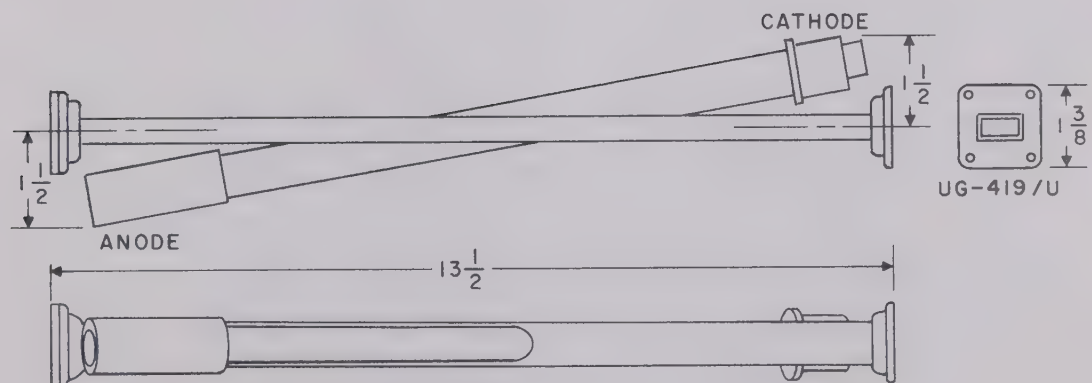
07050



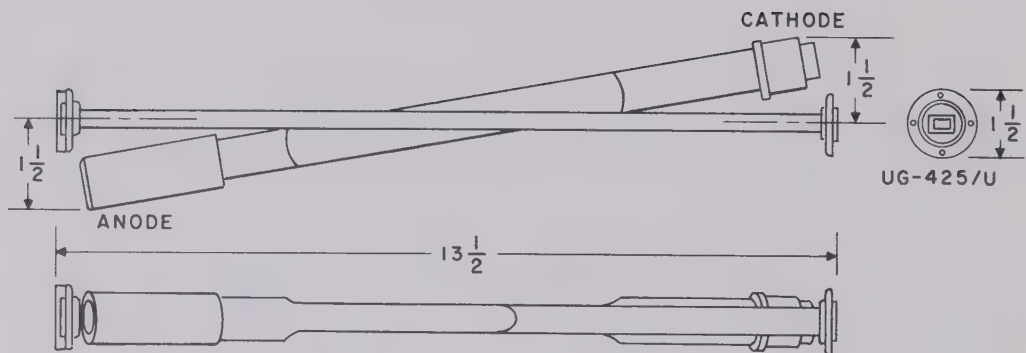
07051



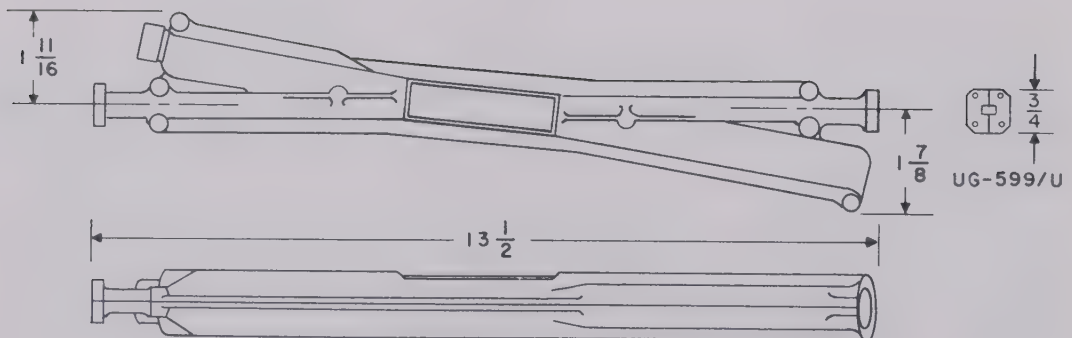
07052



07091



07053



07096

V. THEORY OF OPERATION

Waveguide Noise Generators make use of the positive column of a gaseous discharge as a broad-band untuned resistive termination for a waveguide. If the insertion angle of the gas discharge tube is small, there is very little reflection from the discharge. The minimum insertion angle is determined from the additional consideration that, as insertion angle decreases, reflections due to the cutaway guide walls increase.

Performance is optimized by locating the discharge tube in the E-plane, entering the waveguide through the broad faces. Hence, the greatest linear dimension of the cutaway portion of the guide wall is parallel to the current flow in the wall. This leads to a minimum reflection when the discharge is turned off. Thus, transmission through the waveguide section containing the discharge tube is accomplished with negligible loss.

The noise temperature (T_2) of the gas discharge tube is virtually independent of ambient temperature. A variation of discharge current of the order of +20 percent of peak value will produce an average change of excess noise ratio of only -0.003 dB/mA.

Type 70 Waveguide Noise Generators can be used in any of the standard setups for performing noise-figure measurements of receivers in the 2.6 to 40 GHz range. Basically, these methods involve the measurement of the Y-factor, which is defined as the ratio of the noise output power of the receiver with the noise generator on to that with the noise generator off.

The general formula for deriving the noise figure (F) of a microwave receiver (using a gas-discharge type noise source) is as follows:

$$F = \frac{\left(\frac{T_2}{T_0} - 1 \right) - Y \left(\frac{T_1}{T_0} - 1 \right)}{Y - 1}$$

where

T_2 = electron temperature of the discharge in degrees Kelvin (generator "on"),

T_1 = temperature of the termination in degrees Kelvin (generator "off"),

$T_o = 290^\circ\text{K}$,

Y = ratio of the noise output power of the receiver with the noise generator on, to that with the noise generator off.

In most practical cases, $T_1/T_o \approx 1$, so that the above formula reduces to:

$$F = \frac{\left(\frac{T_2}{T_o} - 1 \right)}{Y - 1}$$

$$F_{\text{dB}} = 10 \log \left(\frac{T_2}{T_o} - 1 \right) - 10 \log (Y - 1)$$

Instead of actual computation, noise figure can be determined from Figure 2 if the excess noise ratio (T_{ex}) of the noise source (see Section II) is equal to one of the values shown in Figure 2. Excess noise ratio is defined:

$$T_{\text{ex}} = \frac{T_2}{T_o} - 1$$

$$T_{\text{ex}} \text{ dB} = 10 \log \left(\frac{T_2}{T_o} - 1 \right)$$

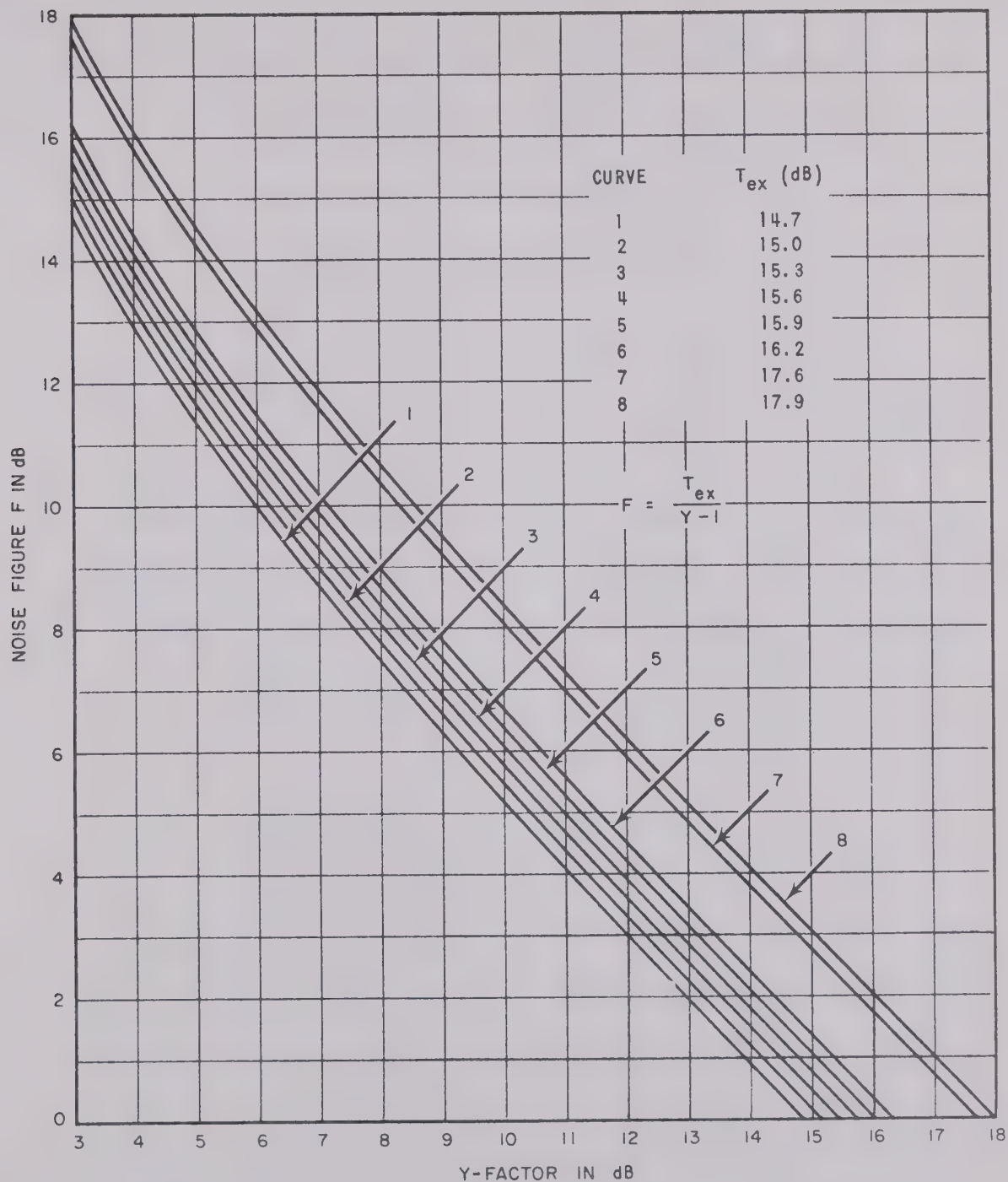


FIGURE 2. MEASURED NOISE FIGURE

If the excess noise ratio of the noise source is other than one of the values shown in Figure 2, noise figure can be determined as follows:

1. Determine noise figure from the graph (Figure 2), assuming $T_{ex} = 15.3$ dB.
2. The correct noise figure is determined from

$$F_{actual} = F_{graph} + T_{ex} - 15.3 \text{ dB}$$

Alternatively, the AIL Noise Figure Slide Rule, which makes provision for a spread in excess noise ratio, can be used to perform the calculation.

This discussion assumes that the effective temperature of the generator in the on condition is equal to that of the discharge. This is true if the coupling to the discharge is complete. If this is not the case, there is a reduction in the output noise. A measure of this coupling is the insertion loss of the generator in the fired condition. This loss is easily measured and provides the best means of computing this correction.

The expression for this reduction is

$$\frac{T'_{ex}}{T_{ex}} = 1 - \frac{1}{L_H}$$

where

T'_{ex} = excess noise ratio of the generator,

T_{ex} = excess noise ratio of the noise tube,

L_H = hot insertion loss of the generator = $\frac{P_{in}}{P_{out}}$.

This expression is plotted in Figure 3 as the dB reduction in excess noise ratio as a function of L_H in dB. This value should be subtracted from the noise figure computed above.

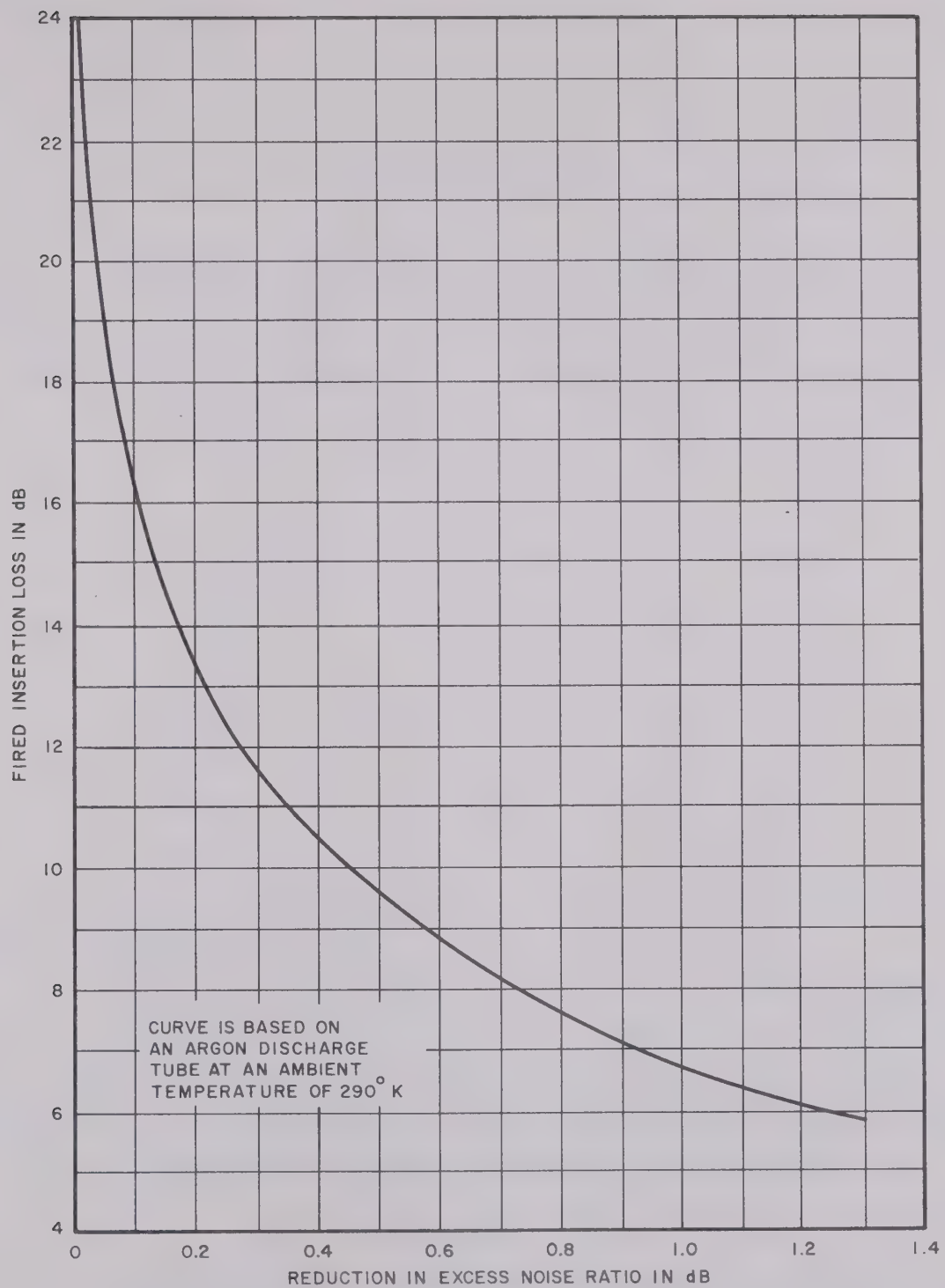


FIGURE 3. FIRED INSERTION LOSS VS REDUCTION IN EXCESS NOISE RATIO

VI. NEON TUBES

Neon Tubes are available for Waveguide Noise Generators. The excess noise ratio of neon noise lamps is generally 2 to 3 dB higher than that of the units employing argon. The Table lists the most commonly encountered neon noise lamps, the associated noise generator, and their excess noise ratio $\left(\frac{T_2}{T_0} - 1 \text{ or } T_{\text{ex}}\right)$ in dB.

<u>Noise Generator</u>	<u>Tube Type</u>	<u>T_{ex} (dB)</u>
07048	TD-34	17.80
07049	TD-48	17.70
07050	TD-23	18.00
07051	TD-54	18.00
07052	TD-54	18.00
07091	TD-50	18.05
07053	TD-50	18.05

The tube type numbers shown are those of the manufacturers, Signalite Incorporated of Neptune, New Jersey.

Noise figure can be calculated from a Y factor measurement as indicated in the handbook using the equations on pages 9 and 10. This requires the insertion of the proper value of the quantity $T_2/T_0 - 1$ (T_{ex}) from the table. Alternatively, the AIL Noise Figure Slide Rule may be used, since it provides for relative excess noise temperatures covering a wide range of values.

NOTE

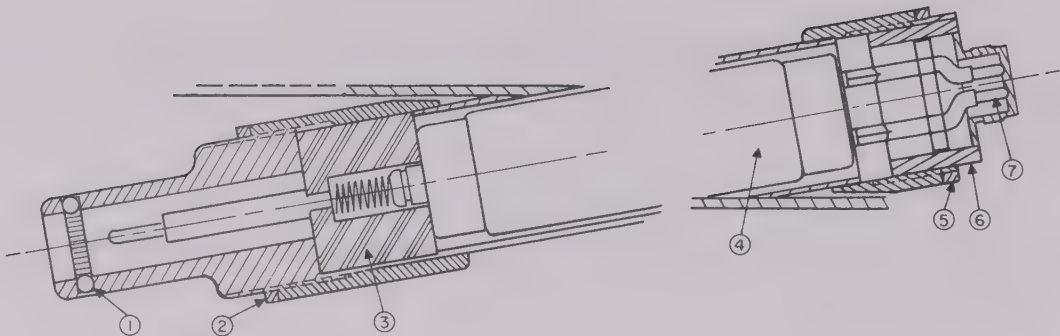
When used with an AIL Type 74 Automatic Noise Figure Indicator, neon noise tubes quite often will not completely deionize or remain deionized when the **MANUAL OFF** button on the ANFI is depressed. The tube will continue to pulse on and off at a relatively low current. This condition could lead to a serious error when making manual

noise figure measurements. The handbook of instructions for the Type 74 describes a modification which eliminates this problem. AIL Application Engineering Bulletin No. 70-25 also describes the modification.

VII. MAINTENANCE

Maintenance of Type 70 Waveguide Noise Generators is limited to replacement of the argon discharge tube. If the tube does not fire, it should be replaced.

The procedure for removing the tube varies with the different types of generators. Detailed removal instructions for generator and replacement parts list follow.

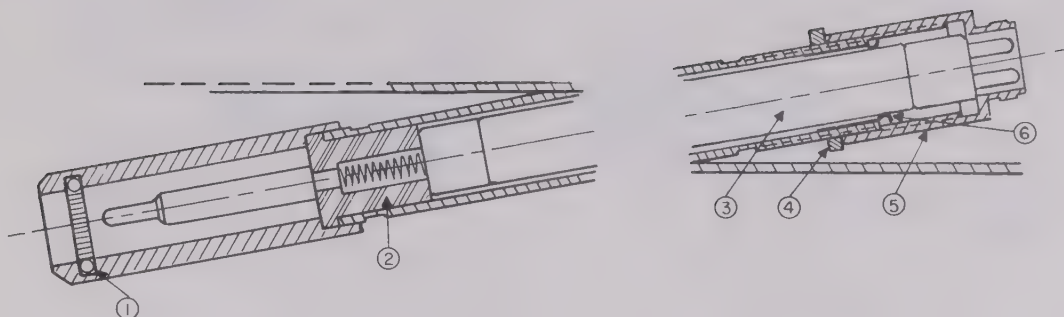


07048

1. Loosen the locknut (5).
2. Unscrew cathode connector housing (6).
3. Remove tube (4) by withdrawing it from generator.
4. Remove cathode contact adapter (7) from tube (4).
5. Insert replacement tube and assemble in reverse order.

SPARE PARTS

<u>Symbol</u>	<u>Description</u>	<u>AIL Part No.</u>
1	SPRING	113974
2, 5	LOCKNUT	116815
3	ANODE CONTACT ASSEMBLY	116812
4	TUBE, NOISE SOURCE	116898
6	CATHODE CONNECTOR	116810
7	CATHODE CONTACT ADAPTER	112977-3
	TERMINATION	207295-1

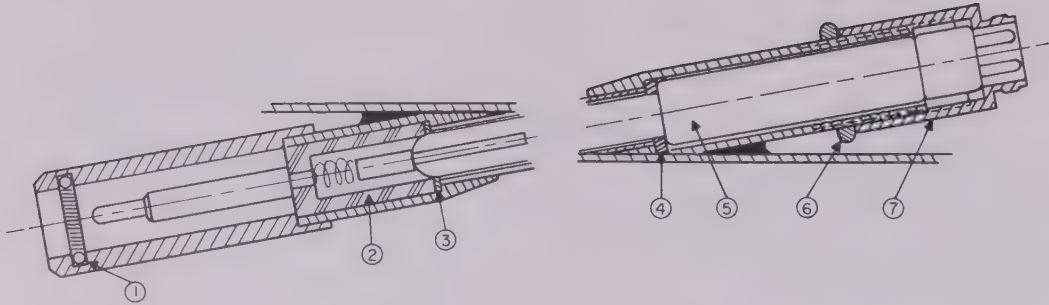


07049

1. Loosen locknut (4).
2. Unscrew cathode connector housing (5).
3. Remove tube (3) by withdrawing from generator.
4. Contact strip (6) may come out with tube. Replace as shown.
5. Insert replacement tube and assemble in reverse order.

SPARE PARTS

<u>Symbol</u>	<u>Description</u>	<u>AIL Part No.</u>
1	SPRING	113974
2	ANODE CONTACT ASSEMBLY	116826
3	TUBE, NOISE SOURCE <i>Signalite 7999/</i>	113827 <i>TD-39</i>
4	LOCKNUT	116829
5	CATHODE CONNECTOR	116830
6	CONTACT STRIP	116831
	TERMINATION	207295-2

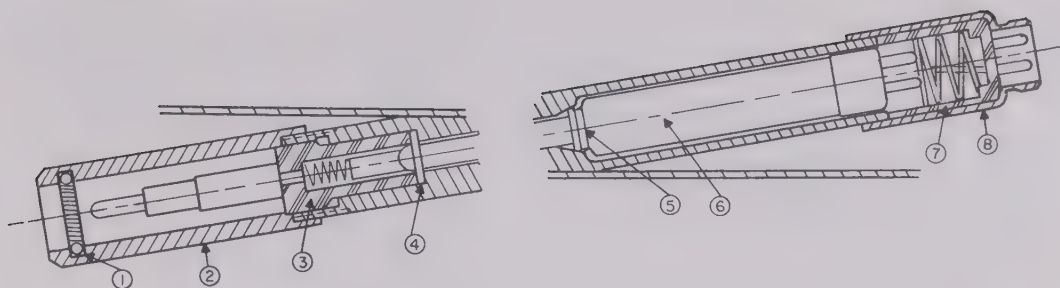


07050

1. Loosen lock ring (6).
2. Unscrew cathode connector housing (7).
3. Remove tube (5) by withdrawing from generator.
4. Replace spacer (4) as shown.
5. Insert replacement tube and assemble in reverse order.

SPARE PARTS

<u>Symbol</u>	<u>Description</u>	<u>AIL Part No.</u>
1	SPRING	113974
2	ANODE CONTACT ASSEMBLY	116610
3, 4	SPACER	116611
5	TUBE, NOISE SOURCE	116613 8059/TD 72
6	LOCKNUT	116829
7	CATHODE CONNECTOR	116830
	TERMINATION	207295-3

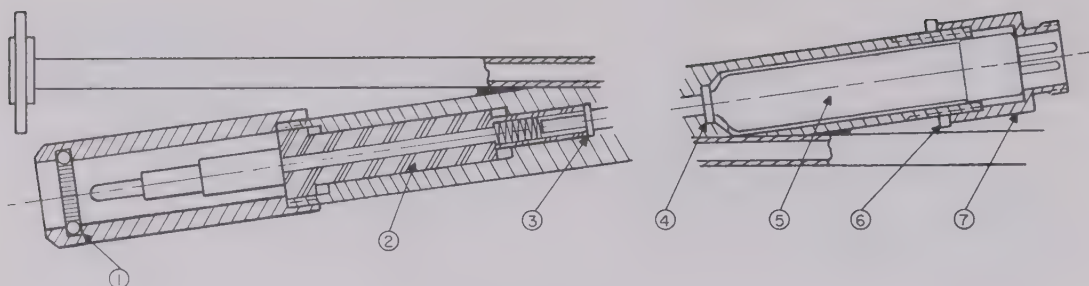


07051 & 07052

1. Remove filament connector ring (8).
2. Remove contact assembly (7).
3. Remove tube (6) by withdrawing from generator.
4. Put O-rings (5) on new tube.
5. Insert tube and assemble in reverse order.

SPARE PARTS

<u>Symbol</u>	<u>Description</u>	<u>AIL Part No.</u>
1	SPRING	113974
2	ANODE SLEEVE	116840
3	ANODE CONTACT ASSEMBLY	116837
4	SPACER	116841
5	O-RING	MS 28775-010
6	TUBE, NOISE SOURCE	AIL 206800 TD 92
7	CONTACT ASSEMBLY	206869
8	FILAMENT CONNECTOR	207189
	TERMINATION FOR 7051	207295-4
	TERMINATION FOR 7052	207295-5

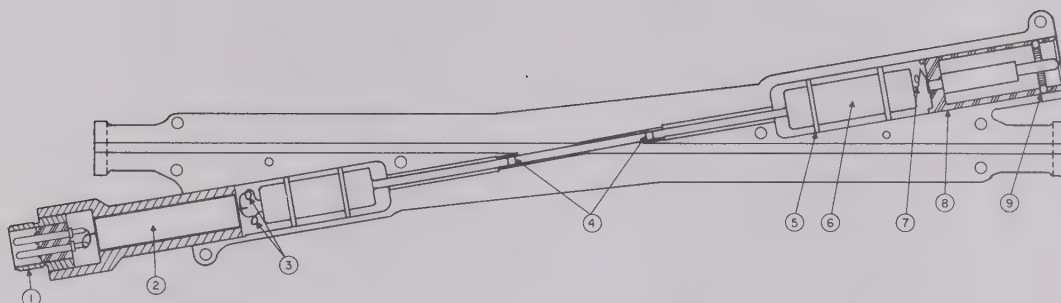


07053 & 07091

1. Loosen lock ring (6).
2. Unscrew cathode connector housing (7).
3. Remove tube (5) by withdrawing from generator.
4. Replace spacer (4) as shown.
5. Insert replacement tube and assemble in reverse order.

SPARE PARTS

<u>Symbol</u>	<u>Description</u>	<u>AIL Part No.</u>
1	SPRING	113974
2	ANODE CONTACT	118789
3	ANODE SPACER	118792-1
4	CATHODE SPACER	118792-2
5	TUBE, NOISE SOURCE	118790
6	LOCKNUT	116829
7	CATHODE CONNECTOR	118781
8	ANODE SLEEVE	116840
	TERMINATION FOR 7053	207295-7
	TERMINATION FOR 7091	207295-6



07096

SPARE PARTS

<u>Symbol</u>	<u>Description</u>	<u>AIL Part No.</u>
1	CATHODE CONTACT	113653
2	RESISTOR	206917-1
4	PAD (4)	114442
5	WASHER (4)	114439
6	TUBE, NOISE SOURCE	114410
8	ANODE CONNECTOR	114441
9	SPRING	113974

1. Remove all screws on top of unit.

NOTE

It is important to avoid marring the internal waveguide surfaces or the mating surfaces. A suggested method of separating the two halves of the generator is to use wooden or plastic wedges that fit in the waveguide ends. Gently pry both halves apart, keeping the mating surfaces parallel. This will expose the tube for replacement.

2. On the bottom of the upper mount are two small Teflon pads (4). These pads are held in place with a small amount of silicone grease and may adhere to the noise tube (5). These pads should be removed and saved for reassembly.
3. Unsolder the flexible leads (3, 7) from the tube pins and remove the tube from the lower half of the mount. Locate the two additional Teflon pads and save them. Also save the flexible leads and four silicone rubber washers (5).

NOTE

The replacement tube mentioned in the following procedure is delicate and expensive. Use utmost care and caution in handling.

4. The replaced tube is installed as follows:
 - a. Scrape terminals at both ends of the tube as close as possible to the glass seal to facilitate soldering.
 - b. Snip off terminals leaving about $\frac{3}{16}$ inch projecting from the end of the tube (both ends).
 - c. Tin the terminals and bend back into the recess at the end of the tube (both ends).
 - d. Soft solder the flexible leads to the tube terminals, avoiding excessive heat. The cathode end has two terminals that should be shorted together.

- e. Place the silicone rubber spacer washers on the bulbous ends of the tube. The notches on the washers should be located on the tube to align with the mating surfaces of the mount.
 - f. If the mount is dirty, clean it with isopropyl alcohol and dry with compressed air.
 - g. Replace the four small Teflon pads in the mount. (Hold in place with small amount of silicone grease if required.)
 - h. Place tube into lower mount assembly and solder pigtail ends of tube to connector and resistor.
 - i. Align hardware and components on the lower half of the mount in their proper positions. (Set screws should fit into detents of the connector housings.)
 - j. Dress flexible leads so that they do not touch side walls of the mount.
 - k. Place upper half mount on lower half assembly and gently but firmly press the upper mount down, keeping both halves parallel.
5. Insert screws and fasten castings tightly together.

VIII. FACTORY REPAIR

If the equipment is to be returned to the manufacturer for repair, please return it in accordance with the following instructions.

1. Write to the Microwave Instruments Sales Department, giving complete information concerning the failure and the manner in which the equipment was being used when failure occurred. Include the unit TYPE and SERIAL numbers.
2. Special shipping instructions will be supplied by AIL. When the shipping instructions are received, pack and ship the equipment as directed. Transportation charges should be prepaid and a failure report should be supplied with the equipment.

